January 16, 2013

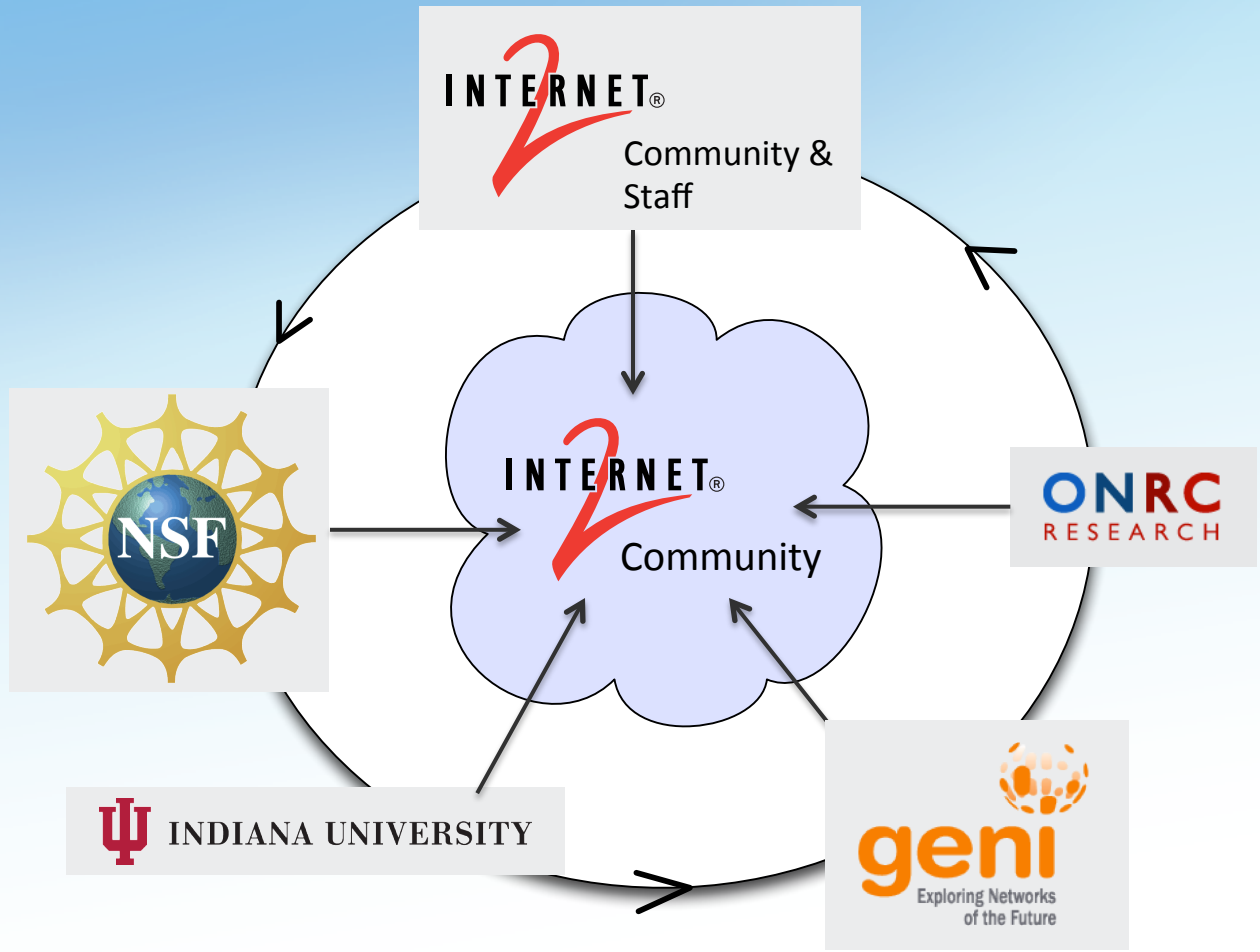
TIP 2013

Eric Boyd, Internet2

Luke Fowler, Indiana University

Internet2 and GENI

Partnership leads to innovation



A bit of history around recent network innovation

- GENI Mesoscale grant begins (Fall, 2009)
  - Internet2 wave contribution, operating Mesoscale backbone nodes
- Community involvement in BTOP Topology (Spring, 2010)
- NTAC/AOAC whitepaper calling on Internet2 to build an advanced Layer 2 network with OpenFlow/SDN support (Spring 2011)
- Demonstration of 10G, SDN-enabled, NEC-based Layer 2 service (October, 2011)
- Community leaders call to “get out in front” (Fall 2011)
- AOAC discussions on innovation program (Fall/Winter 2011/2012)
- Board support to combine multiple threads and push aggressively forward on a new “innovation program” (Winter 2012)
- RFP issued to challenge the vendor community (Winter 2012)
- Announcement of planned 100G Advanced Layer 2 service (April, 2012)
- Launch of 100G, SDN-enabled, heterogeneous Advanced Layer 2 service (October, 2012)

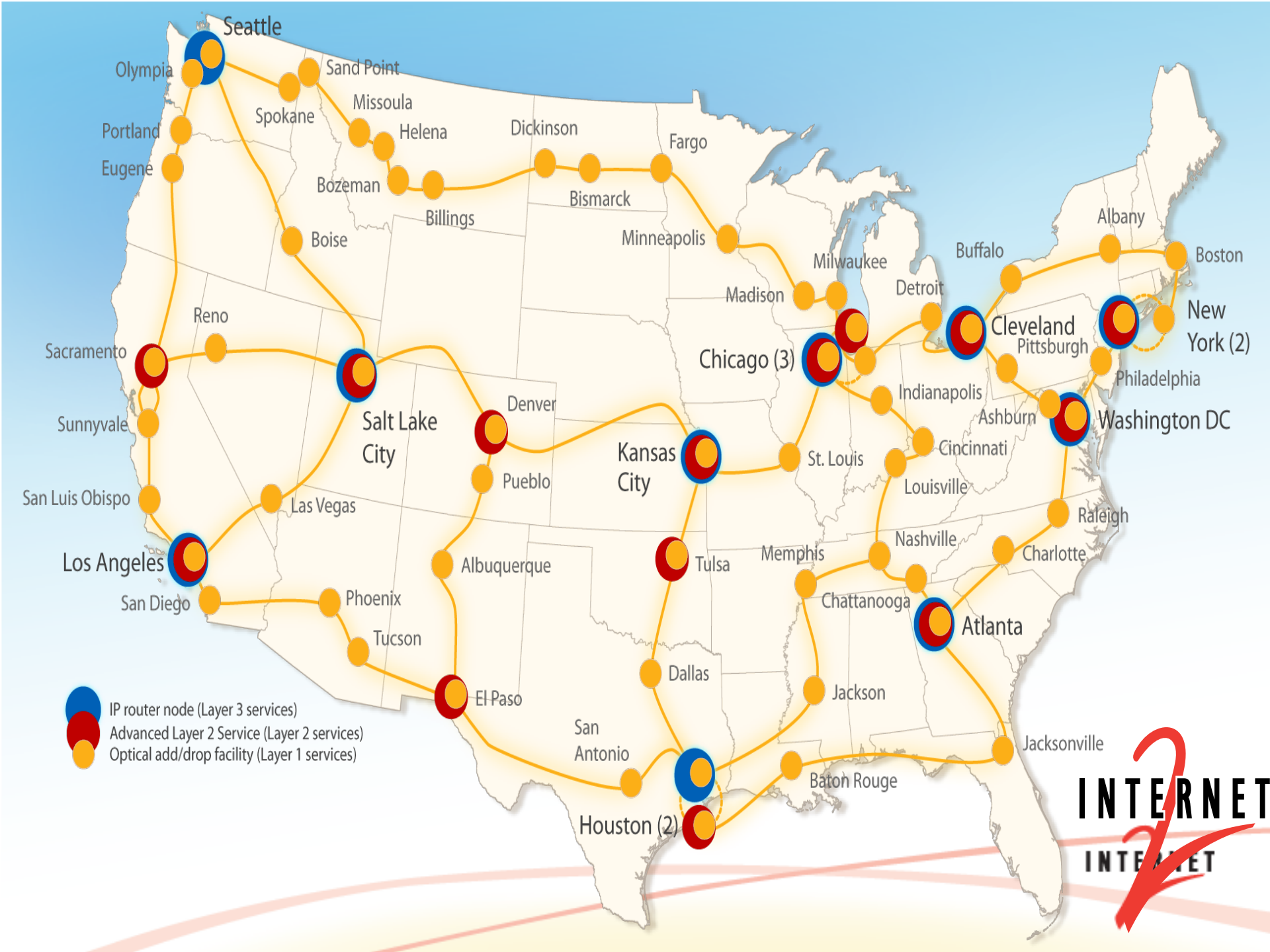
INTERNET 2

Overview

- Infrastructure
  - Services
  - Deployment
- Software
  - What's deployed today
  - Roadmap
  - Partnership
- Engagement with Network Research Community
  - GENI
  - Internet2 Network Research Environment
  - Future Funding Opportunities
  - Future Internet2 Group

Internet2 Service Layers

- Advanced Layer3 Service Network
  - 10 Juniper routers
  - Interconnected via bundles of 10G
- Advanced Layer2 Service Network
  - 14 nodes deployed (growing to ~35)
  - Heterogeneous (Brocade, Juniper, Cisco?, …)
  - Interconnected via 100G
  - 5 node advanced test network (NEC)
- Advanced Layer1 Service Network
  - Only 10/40/100G capable Layer 1 Service in the US
  - 88 channels of 100G capability
  - 56 Add/drop and flexibility to add more
- TR-CPS Network
  - 5 Juniper MX-960 routers
- Interconnects
  - 4x 100GigE and 6x 10GigE between L2 and L3
  - Expect 100G interconnects between L2 and Exchange Points


Seattle
Olympia
Sand Point
Spokane
Missoula
Portland
Helena
Dickinson
Fargo
Eugene
Bozeman
Bismarck
Billings
Albany
Boise
Minneapolis
Buffalo
Boston
Milwaukee
Madison
Detroit
Reno
Cleveland
New York (2)
Sacramento
Chicago (3)
Pittsburgh
Philadelphia
Indianapolis
Denver
Ashburn
Washington DC
Sunnyvale
Salt Lake City
Kansas City
St. Louis
Cincinnati
Pueblo
Louisville
San Luis Obispo
Las Vegas
Raleigh
Nashville
Memphis
Charlotte
Los Angeles
Albuquerque
Tulsa
Chattanooga
San Diego
Phoenix
Atlanta
Tucson
Dallas
Jackson
El Paso
San Antonio
Jacksonville
Baton Rouge
Houston (2)
IP router node (Layer 3 services)
Advanced Layer 2 Service (Layer 2 services)
Optical add/drop facility (Layer 1 services)
INTERNET
INTERNET

AL2S Infrastructure 1st Half 2013

Advanced Layer 2 Service Features (Now)

CORE

- 10G & 100G dedicated ports
- Brocade
- 7x24x365 production-quality support
- Robust evolution and regressive lab testing plan

VLAN PROVISIONING

- User (& backup) VLAN provisioning through GUI
- Ability to reach Internet2 Layer 3 Services
- Ability to reach International Exchange Points at 100G
- Interdomain provisioning to IDC Domains
- Multipoint VLANs

APPLICATION INTERFACE

- IDC API
- OESS API
- Sherpa API

INNOVATION TESTING ENVIRONMENT

- Adoption of Early Vendor Code (Ongoing)
- Automated SDN Test Suite (Ongoing)
- SDN Production Test Platform

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Advanced Layer 2 Service Features (Planned)

- Engagement
  - Ongoing, tight interaction with vendor community
  - Ongoing, tight interaction with research community
- Creating a multi-vendor AL2S
  - Currently Brocade MLXe-16s in AL2S
  - Incorporate Juniper MX 960s into AL2S (2/13)
  - Potentially others
- Creating a network research environment
  - Linked AL2S and GENI Mesoscale Infrastructure (Complete)
  - Deploy GENI Aggregate Manager over ION (1/13)
  - Deploying Flowvisor over AL2S (2/13)
  - Deploying FOAM over AL2S to request circuits (3/13)
  - Expand to support the full GENI API (5/13 and ongoing)

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Innovation Themes

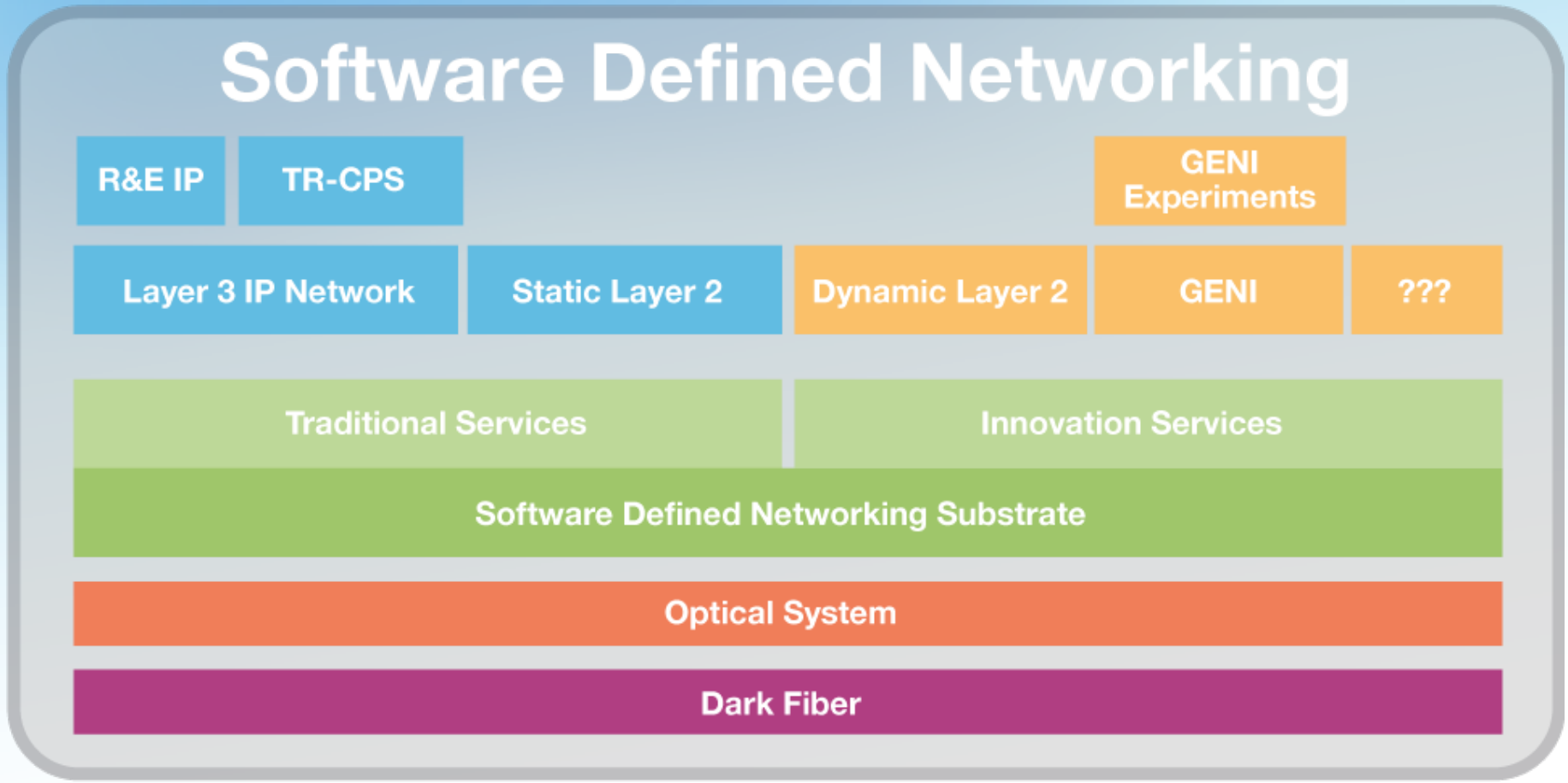
- Heterogeneity is good
- If it doesn't exist, build it
- If its open source, improve it
- If its in the marketplace, stress it and engage vendor
- Build it on the Internet2 network / push it out to the R&E community

Innovation Components

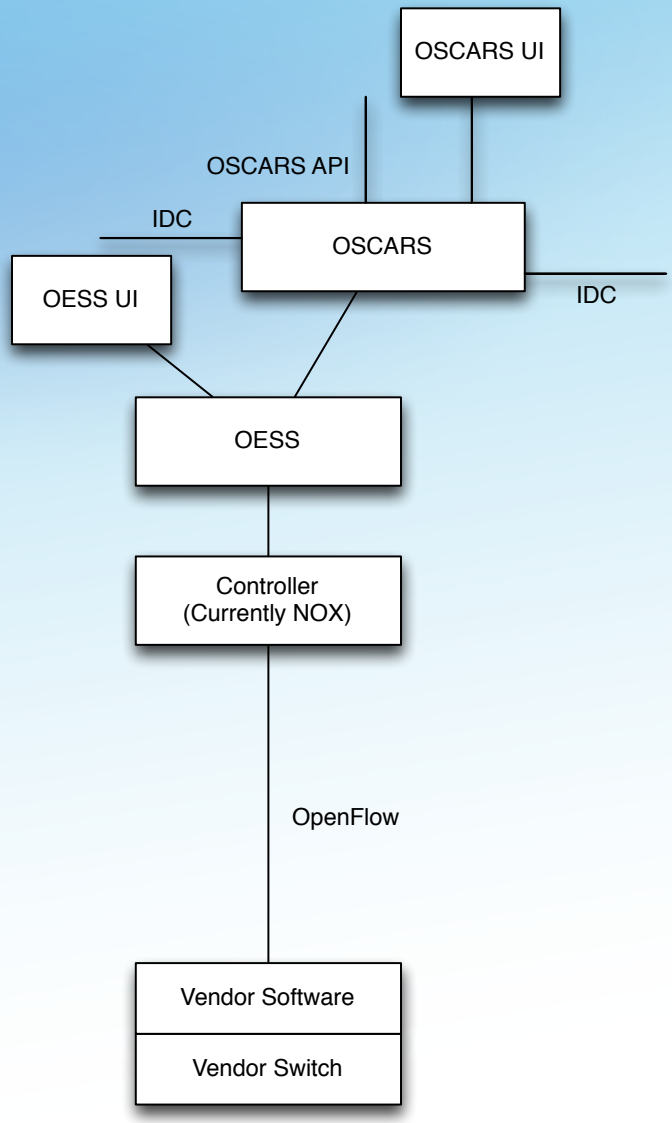
- Hardware
- Virtualization
- Controller
- OESS
- Applications
- Interoperability (at all levels)

INTERNET 2

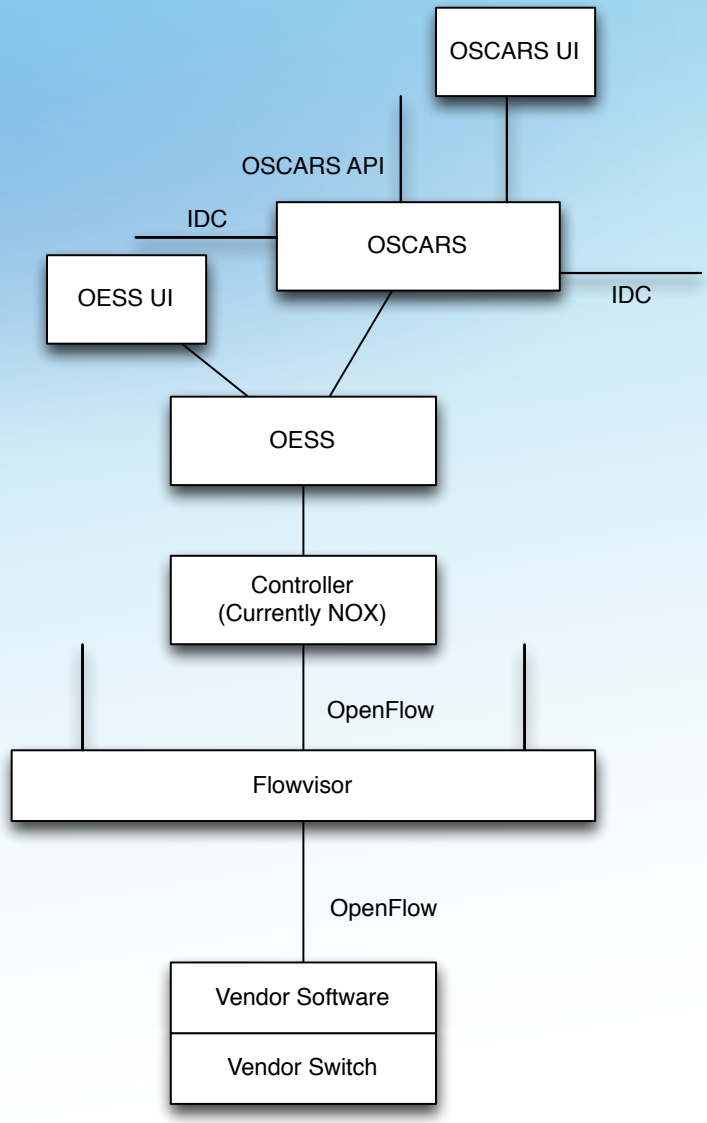
Long-term Architectural Aspiration



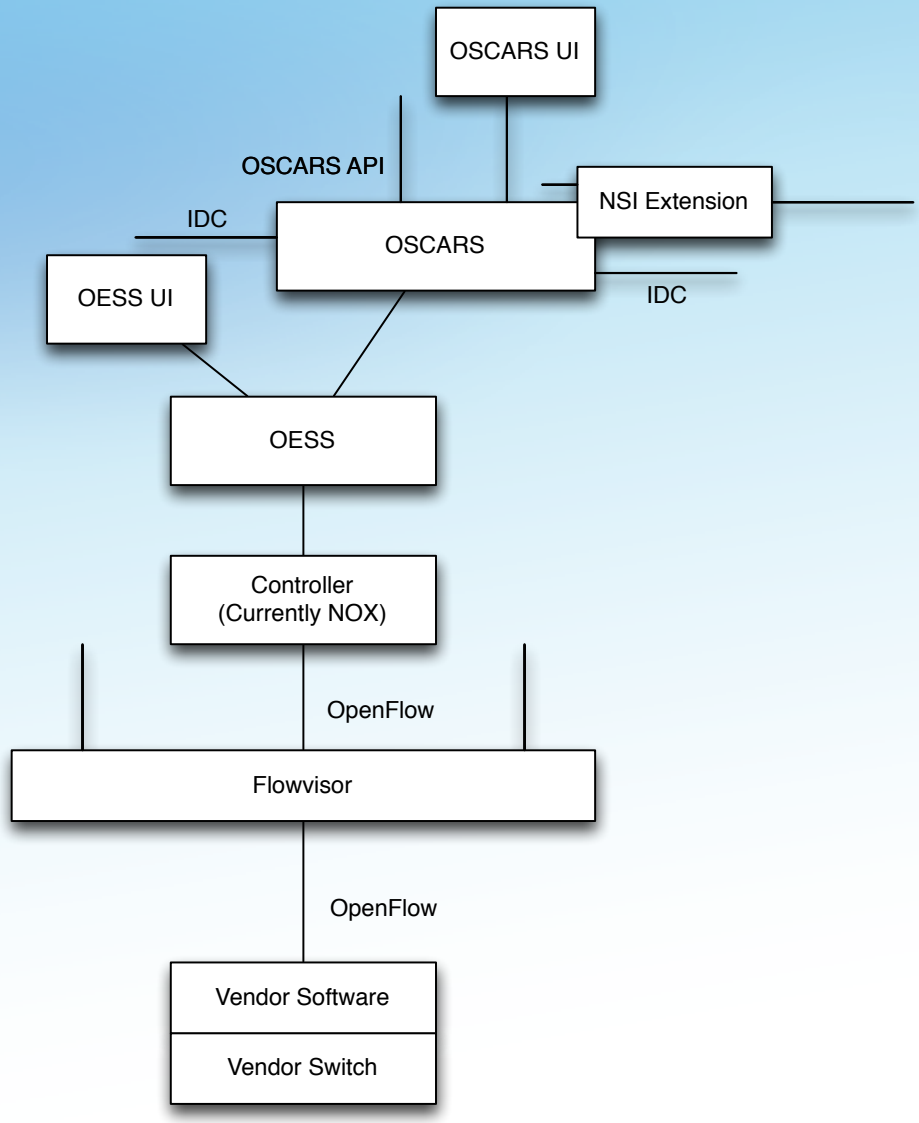
Software Stack — Today



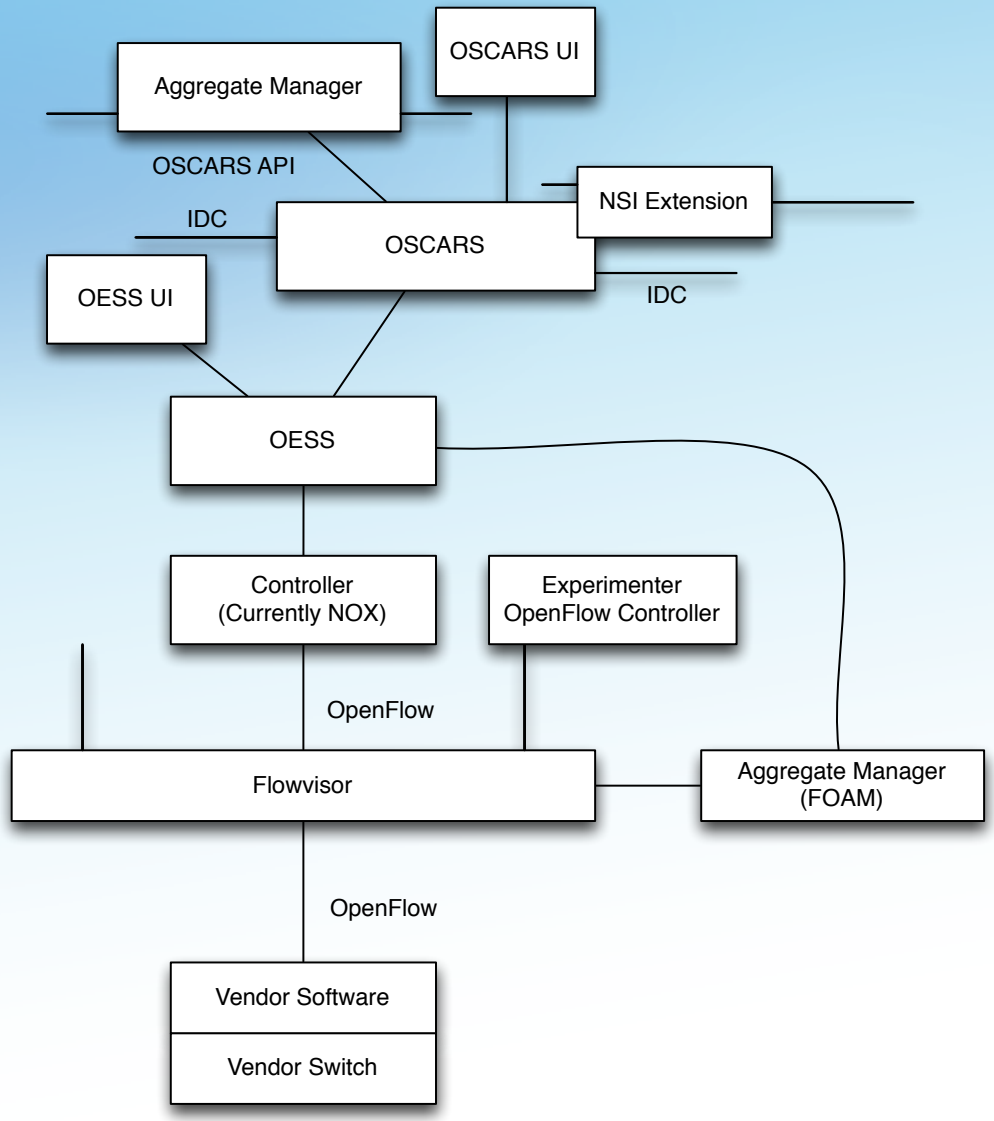
Software Stack — Q1 2013



Software Stack — Future



Software Stack — Not fully baked



Software Development Roadmap

- Deploy Flowvisor on NEC Testbed Environment (January)
  - Modify Flowvisor to not send drop rule upon establishing control session with switch
  - Continue to refine Flowvisor as issues identified in testing
- Deploy OESS on Juniper nodes (February)
  - Hairpin support in OE-SS
- Flowvisor (1 slice only, running OESS) (February)
- Flowvisor (2 slices, both running OESS) (March)
  - Modify Flowvisor to properly slice read-state messages
  - Continue to refine Flowvisor as issues identified in testing and operation
- Flowvisor (multiple slices, running OESS and sample application(s)) (April)
- Flowvisor (N slices, open to pre-approved experimental controllers) (May)
  - Modify Flowvisor to support flow mod and stats rate limits (controller to switch only)
- FOAM / AM with OE-SS extensions running on NDDI (June)
  - Modify FOAM to support circuit provisioning using OE-SS

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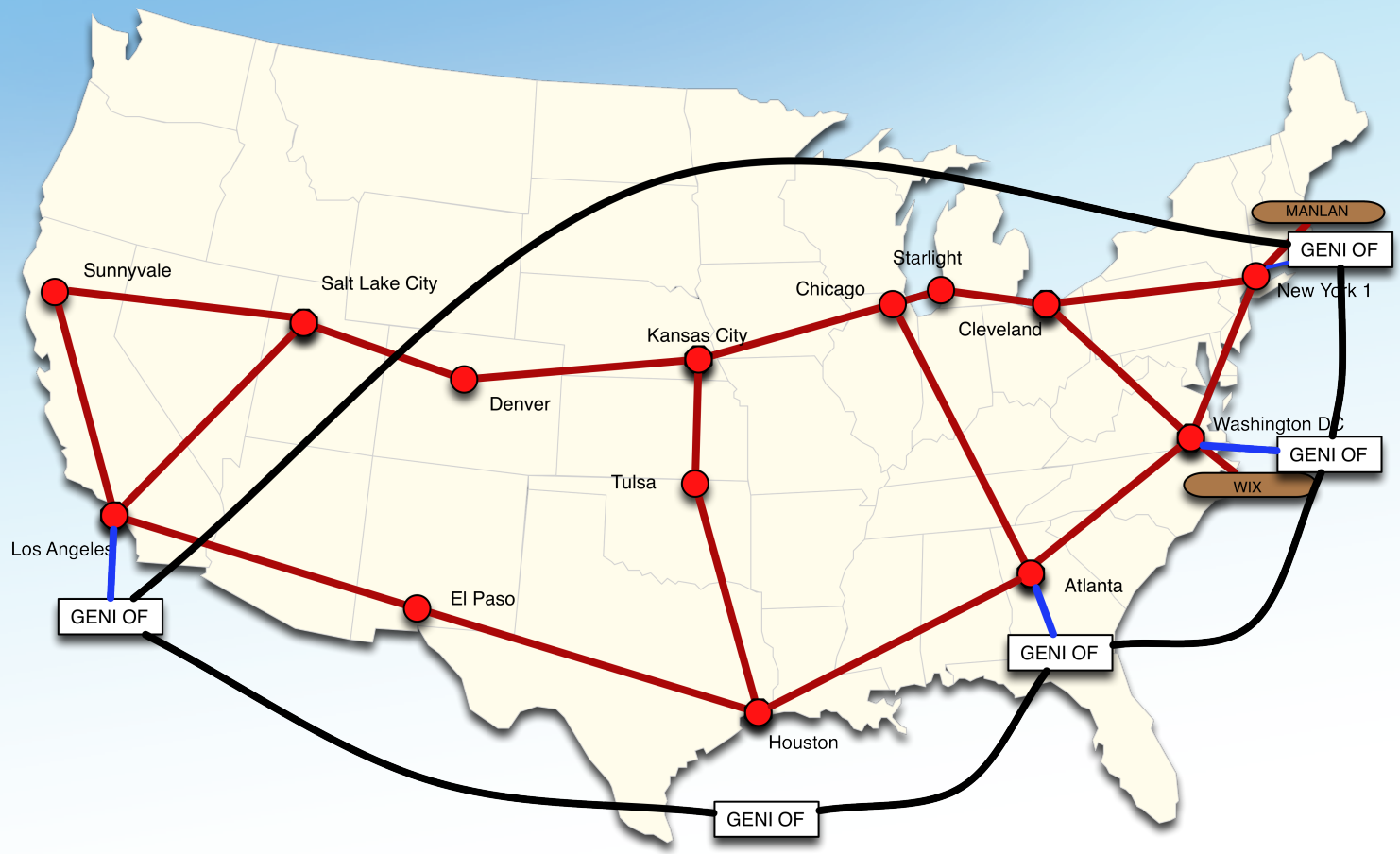
Current GENI Mesoscale infrastructure



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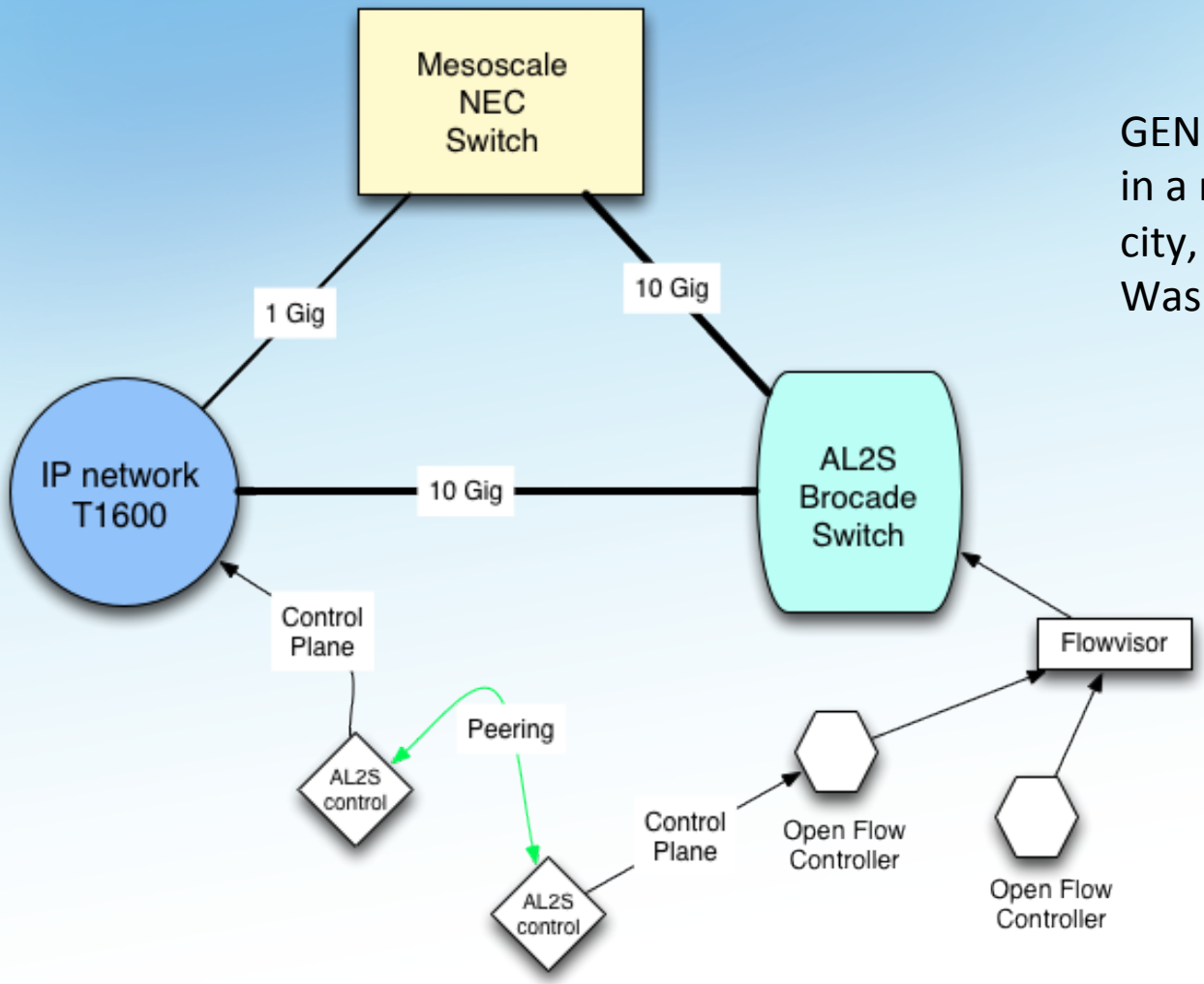
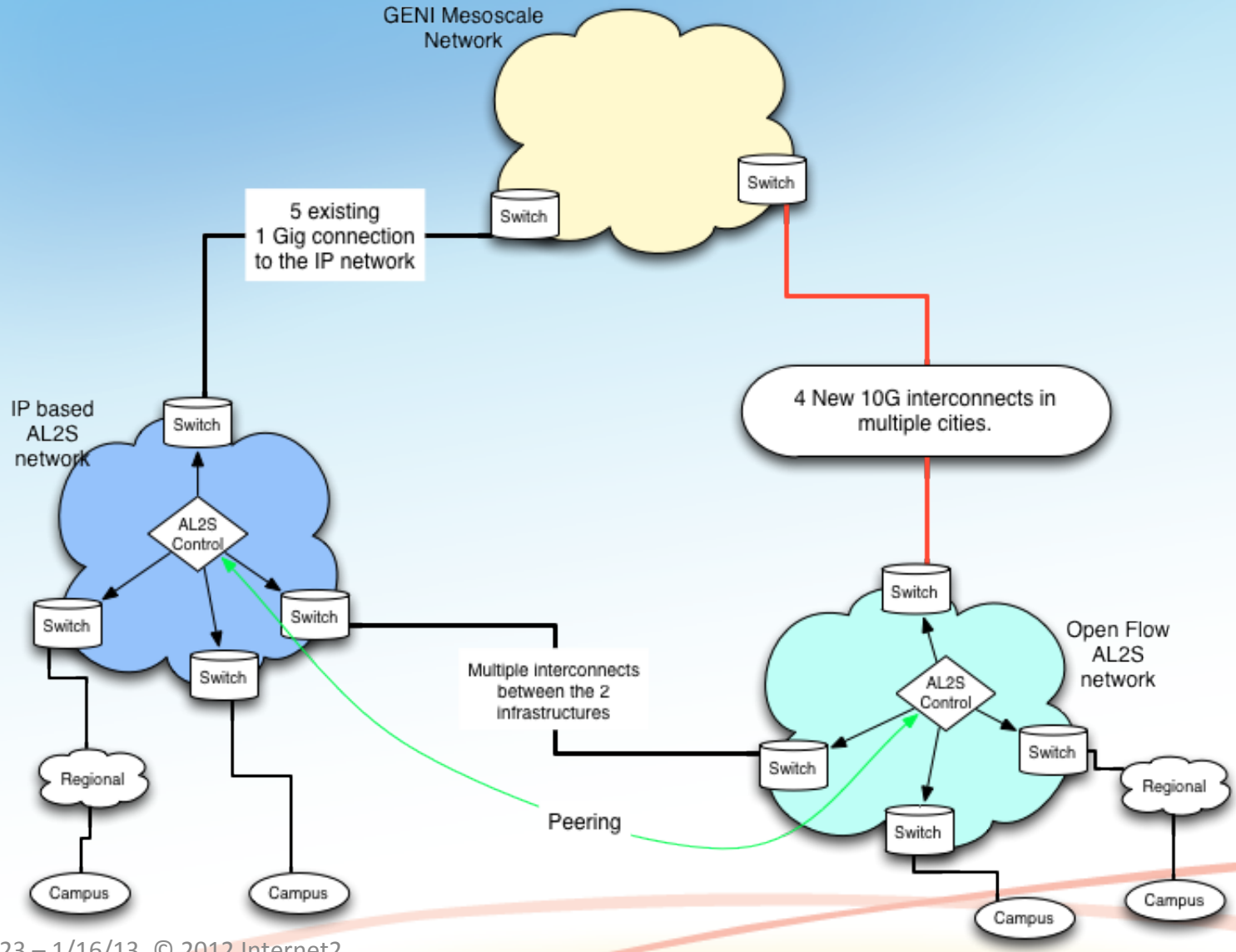


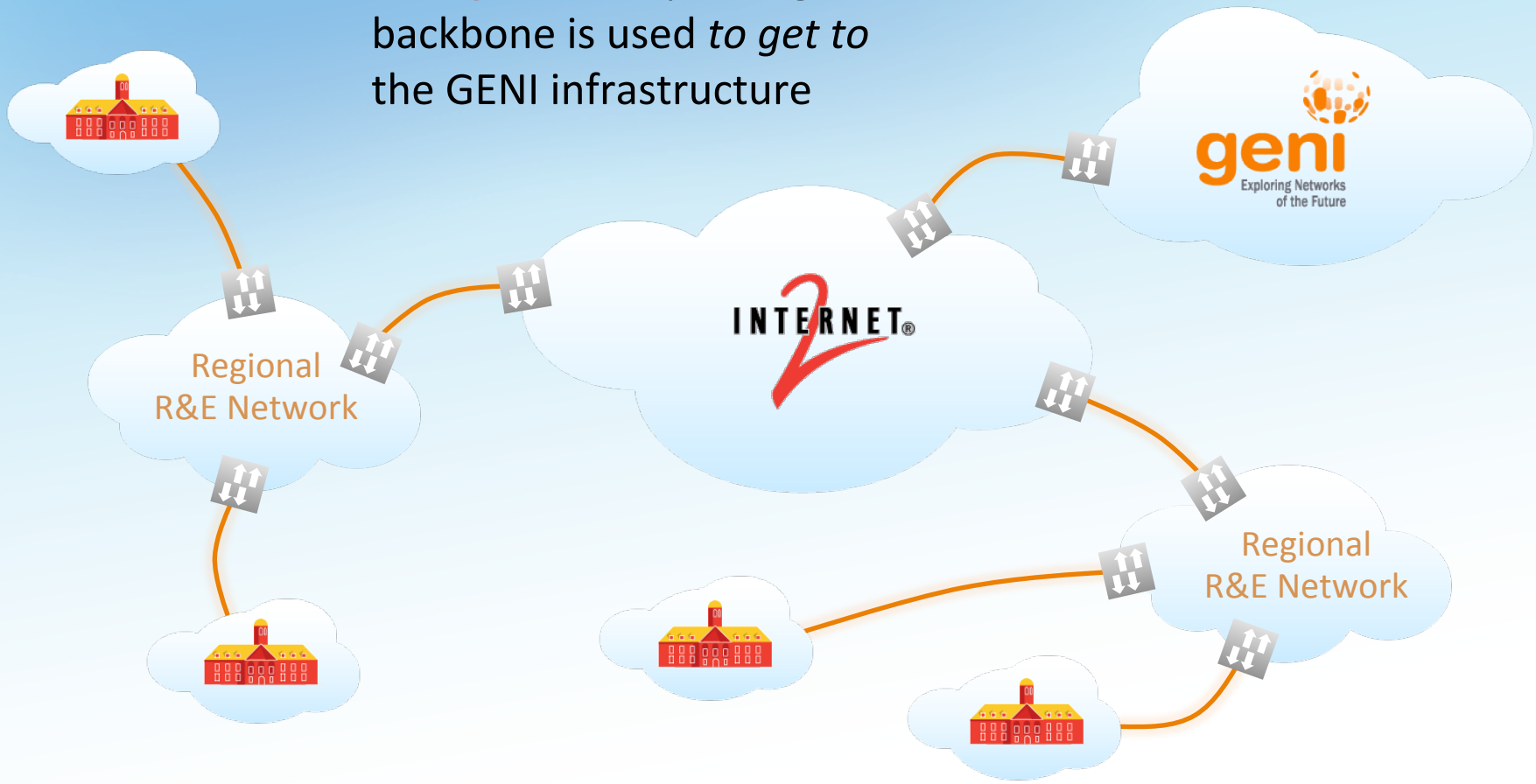
GENI interconnectivity in a representative city, for example, Washington, D.C.

Current GENI Mesoscale infrastructure



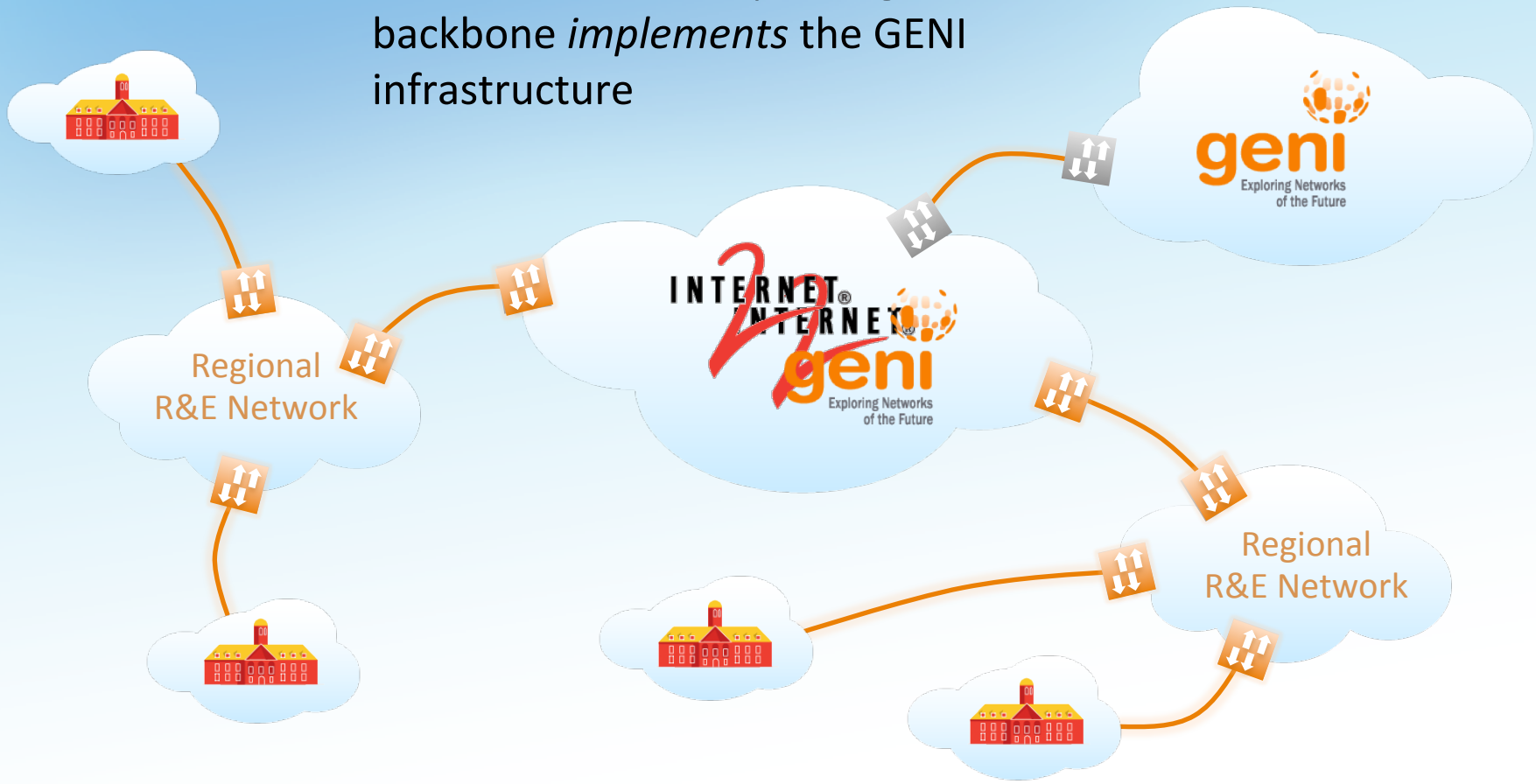
Internet2 and GENI Today

Today, the campus/regional/national backbone is used *to get to* the GENI infrastructure



Internet2 and GENI Tomorrow

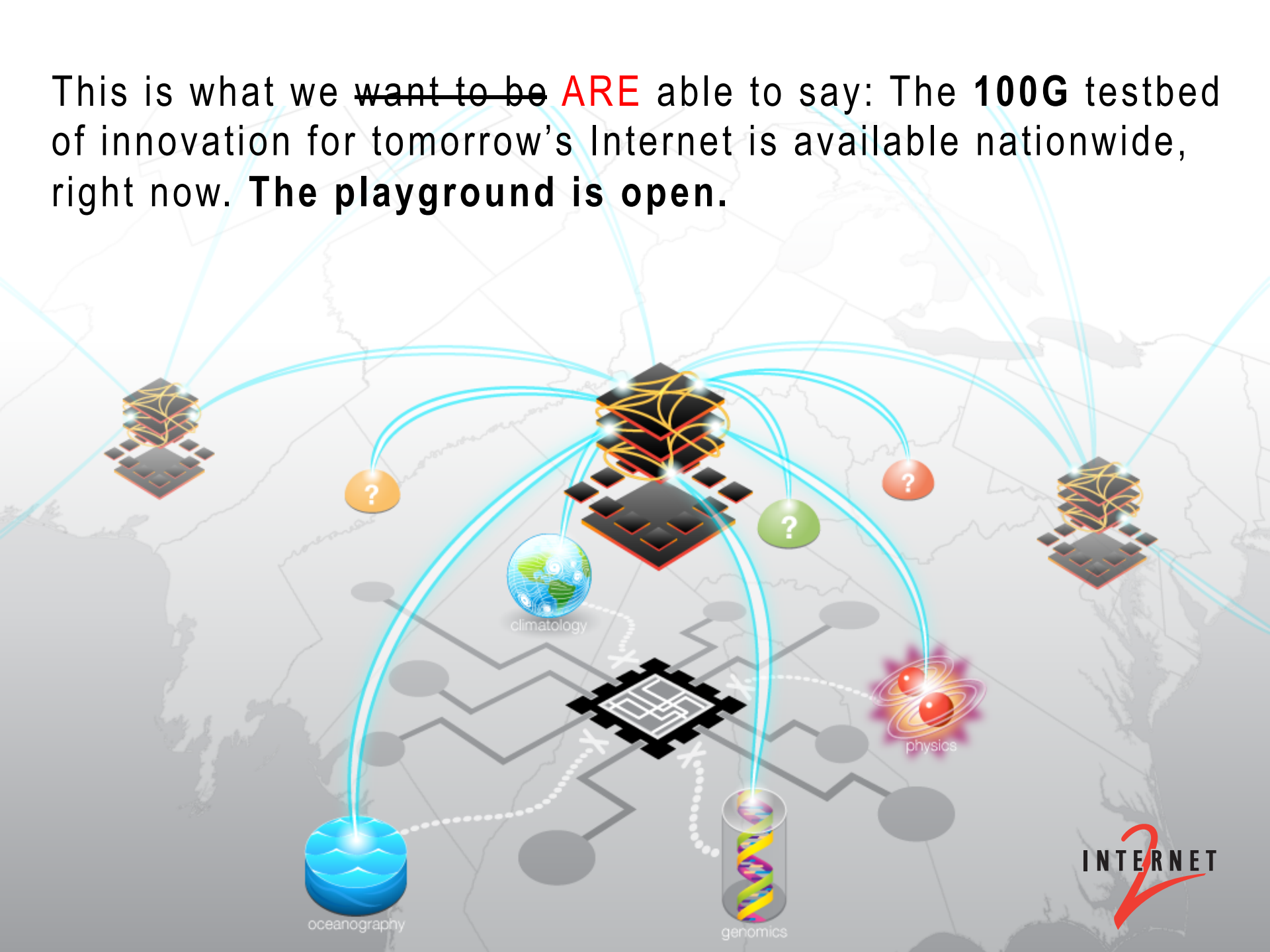
Tomorrow, the campus/regional/national backbone *implements* the GENI infrastructure



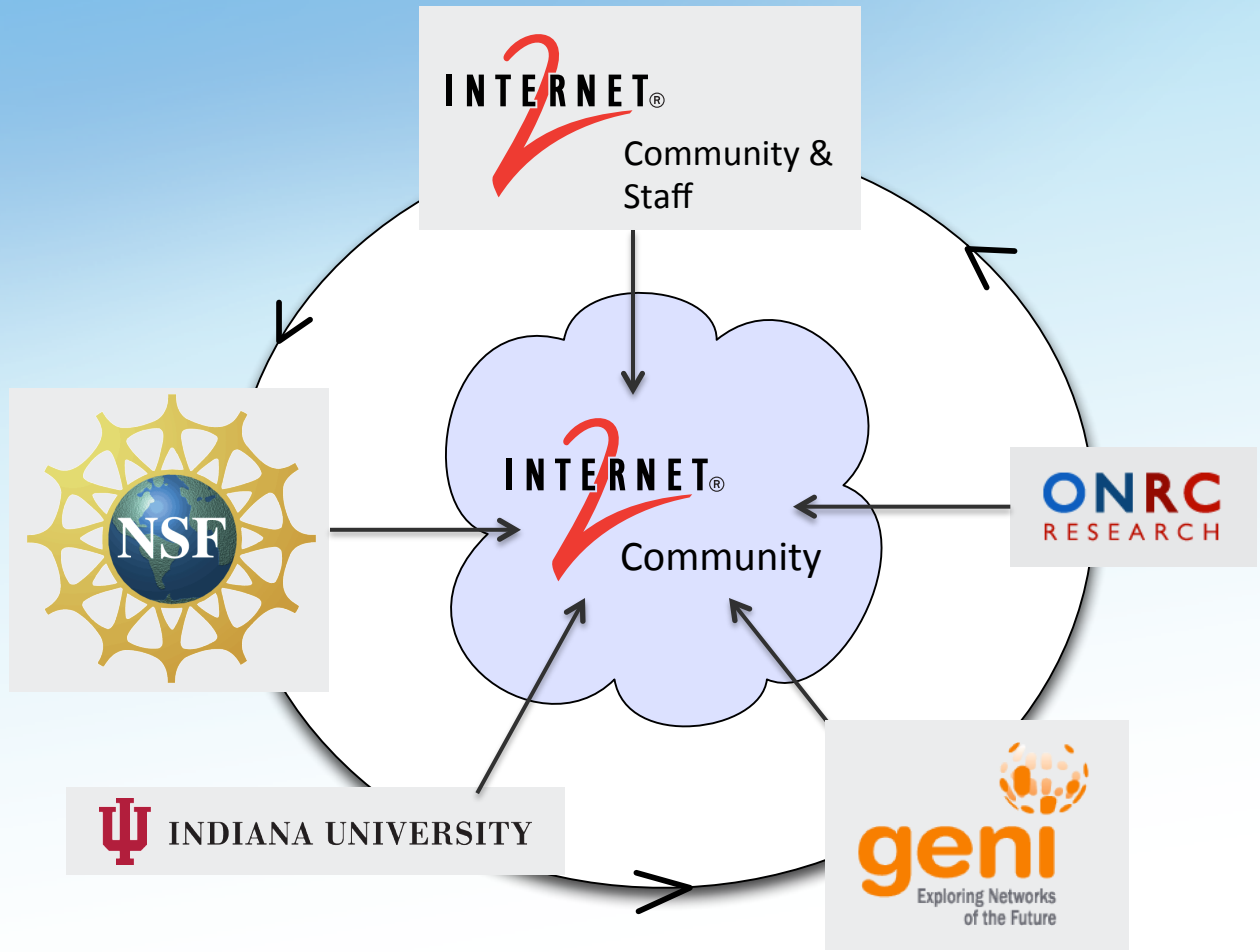
Internet2 and GENI

- GENI environment implemented on the Internet2 backbone
  - Today: The campus/regional/national backbone is used *to get to* the GENI infrastructure
  - Tomorrow: The campus/regional/national backbone *implements* the GENI infrastructure
- Software and operational environment of GENI is supported in a production environment
  - Tomorrow: Aggregate manager API, dynamic stitching, instrumentation and measurement API
  - Next Day: GENI environment continues to evolve to meet needs of network research community

This is what we ~~want to be~~ ARE able to say: The **100G** testbed of innovation for tomorrow's Internet is available nationwide, right now. **The playground is open.**



Partnership leads to innovation



January 7, 2013

NSF CC-NIE Workshop

Rob Vietzke

Internet2 Innovation Platform